Bone Matrix:

1. What are the two main components of bone matrix?
   - The two main components are inorganic and organic components.

2. What percentage of the dry weight of bone does the inorganic component constitute?
   - The inorganic component constitutes about 50% of the dry weight of bone.

3. What are the main constituents of the inorganic component?
   - The main constituents are calcium salts (calcium hydroxyapatite) and phosphate.

4. What percentage of the dry weight of bone does the organic component constitute?
   - The organic component also constitutes about 50% of the dry weight of bone.

5. What are the components of the organic component of bone matrix?
   - The organic component includes collagen fibers

type I, ground substance containing glycosaminoglycans (such as chondroitin sulfate and keratan sulfate), proteoglycans, and glycoproteins.

6. How is the matrix stained in H&E sections?
   - The matrix is stained acidophilic (collagen) in H&E sections and is PAS positive.

Types of Bone Tissue:

Macroscopic Types:

1. What are the two main macroscopic types of bone tissue?
   - The two main types are spongy (cancellous) bone and compact bone.

2. Describe spongy (cancellous) bone.
   - Spongy bone consists of irregular bone trabeculae that branch and unite with one another, enclosing spaces filled with bone marrow.

3. Describe compact bone.
   - Compact bone appears as a solid, very dense

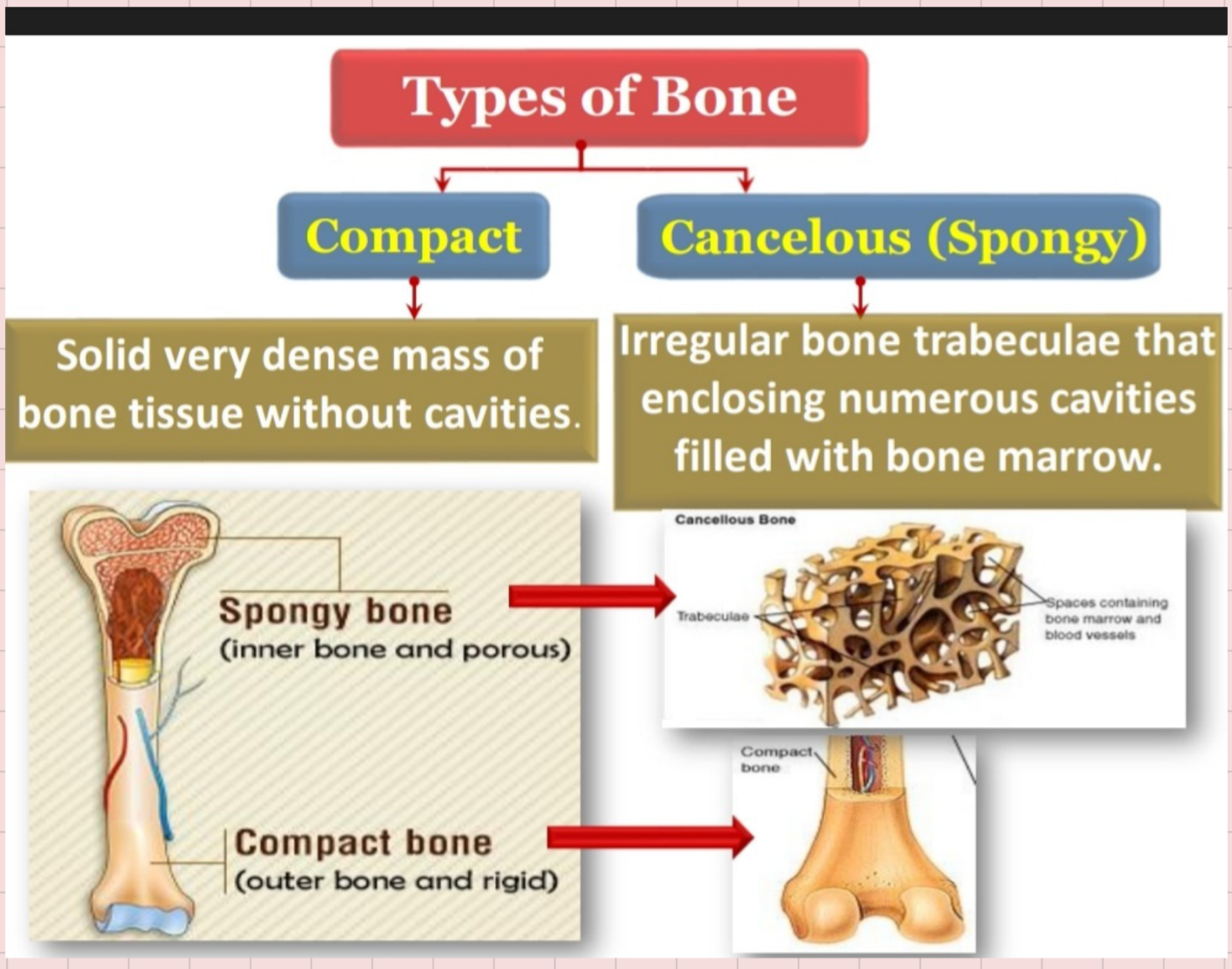
mass of bone tissue without cavities.
Microscopic Types of Bone Tissue:

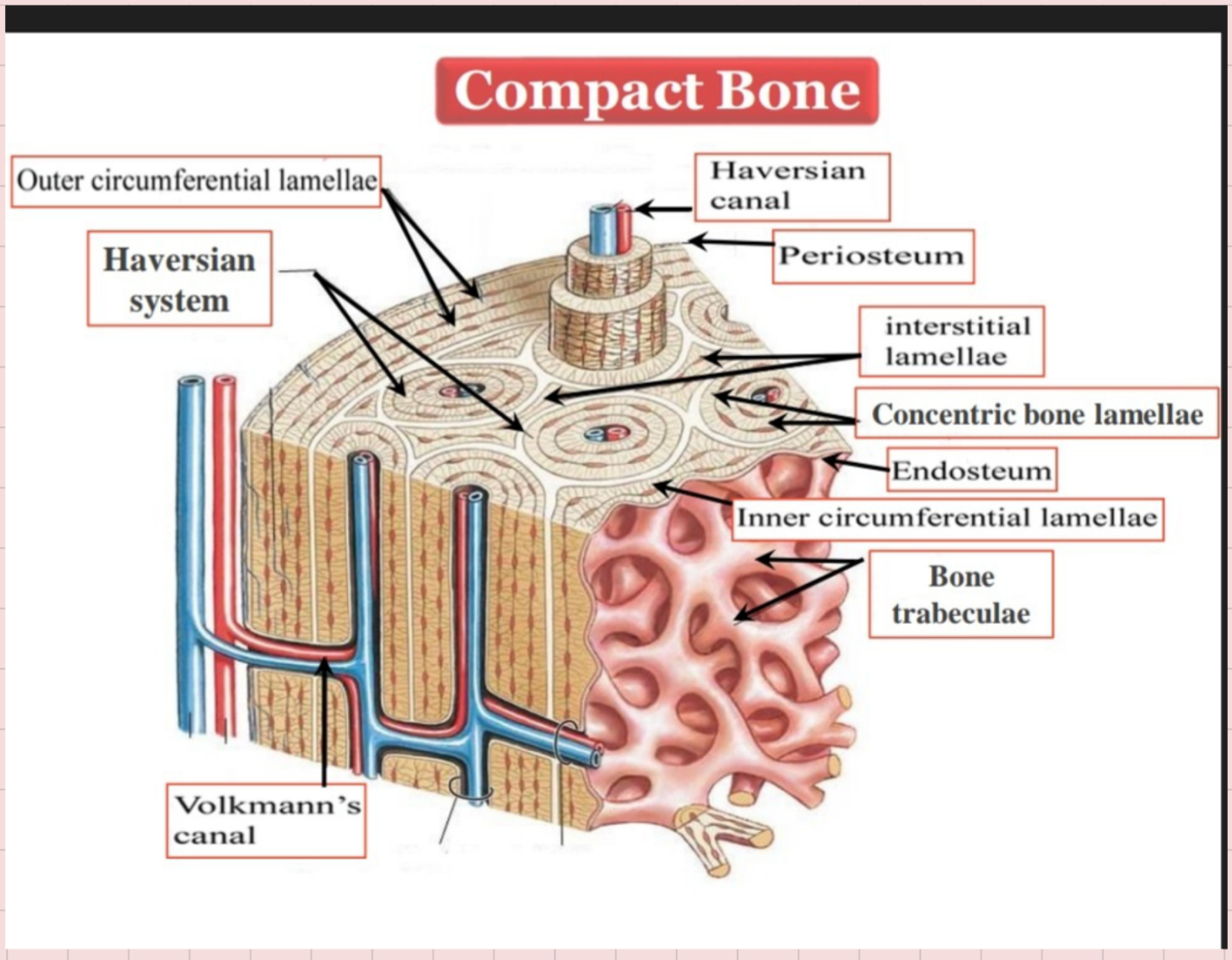
1. What are the two microscopic types of bone tissue?
   - The two types are primary bone (immature or woven bone) and secondary bone (mature or lamellar bone).

2. Describe primary bone (immature or woven bone).
   - Primary bone is the first bone formed during fetal development and bone repair.
   - It has abundant osteocytes and irregular bundles of collagen.
   - Its mineral content (calcium salts) is much less than that of secondary bone.

3. Describe secondary bone (mature or lamellar bone).
   - Secondary bone is found in adults.
   - Collagen fibers are regularly arranged in concentric lamellae, which are parallel to each other around a vascular canal (Haversian canal).
   - Osteocytes in their lacunae are dispersed between or within lamellae.

- The matrix of secondary bone is more calcified, making it stronger than primary bone.





Compact or Decalcified Compact Bone:

1. How many lamellae compose compact bone in the diaphysis of long bones?
   - Compact bone in the diaphysis of long bones is composed of four lamellae.

2. Describe the outer circumferential lamellae.
   - They are located just beneath the periosteum and contain Sharpey's fibers.

3. What is the structure of a Haversian system (osteon)?
   - Each Haversian system is composed of concentric lamellae of regularly arranged collagenous fibers concentric around a vascular canal known as the Haversian canal.

4. What lines the Haversian canal?
   - The Haversian canal is lined with endosteum, which contains osteoblasts and osteogenic cells.

5. What do Haversian canals contain?
   - Haversian canals contain blood vessels and nerves, as well as associated connective tissue.

6. What is the outer boundary of each osteon?
   - The outer boundary of each osteon is a more collagen-rich layer called the cement line.

Compact or Decalcified Compact Bone (Continued):

7. How do Haversian canals run in relation to the long axis of the bone?
   - Haversian canals run parallel to the long axis of

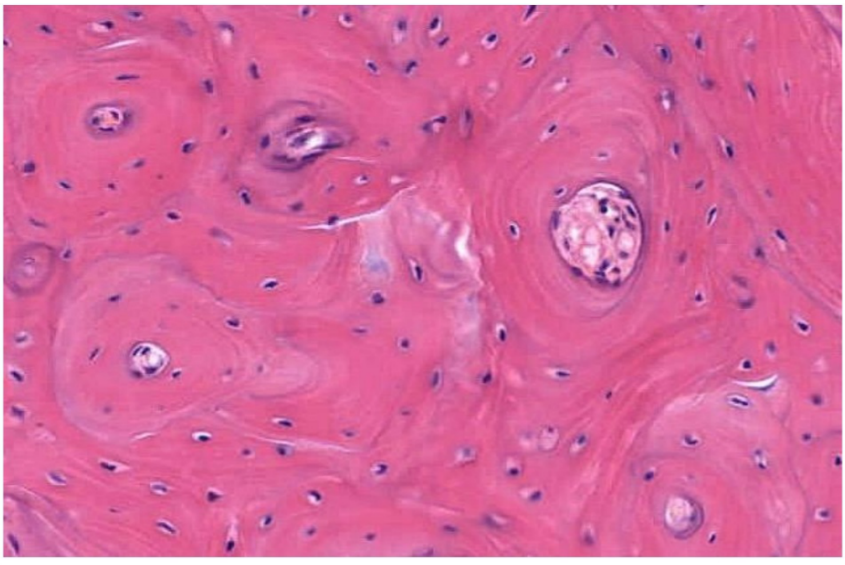
the bone and are connected with each other, with the periosteum, and with the endosteum by transverse or oblique canals known as Volkmann's canals.

8. What is the structure of Volkmann's canals?
- Volkmann's canals are also lined with endosteum and contain blood vessels, nerves, and connective tissue.

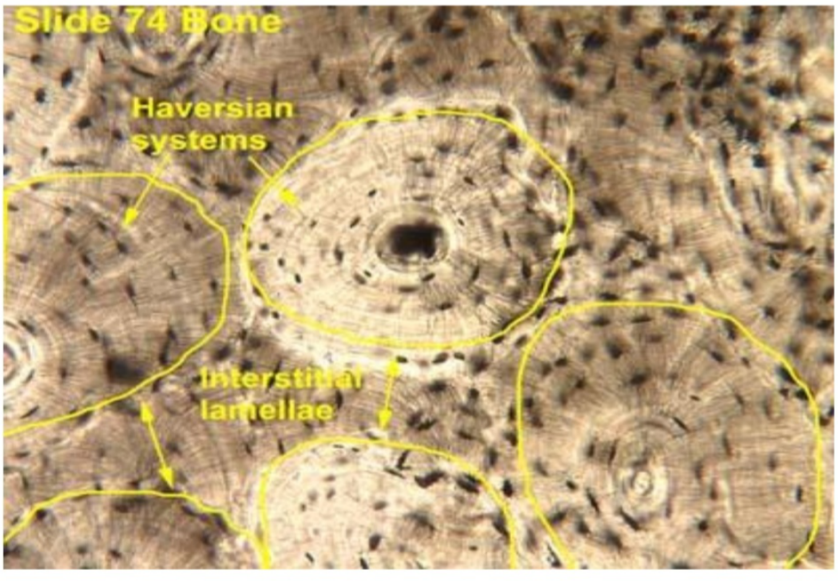
9. Describe the location and function of inner circumferential lamellae.
- Inner circumferential lamellae are located immediately beneath the endosteum and completely encircle the marrow cavity. They have less lamellae than the outer circumferential lamellae.

10. What are interstitial lamellae?
- Interstitial lamellae are the lamellae of bone present between Haversian systems.

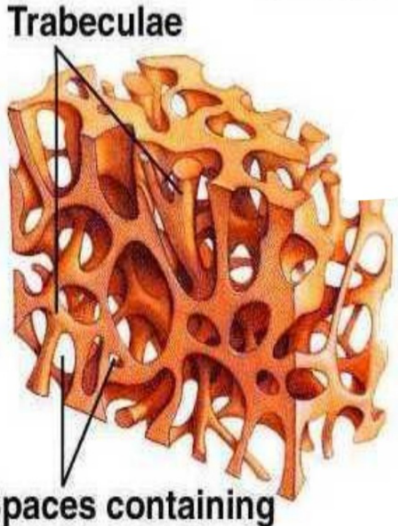
Compact Bone



Compact Bone



Cancellous Bone



Cancellous Bone:

1. Where is cancellous bone typically found in the body?
   - Cancellous bone is present in flat bones such as the skull, sternum, ribs, and ends of long bones.

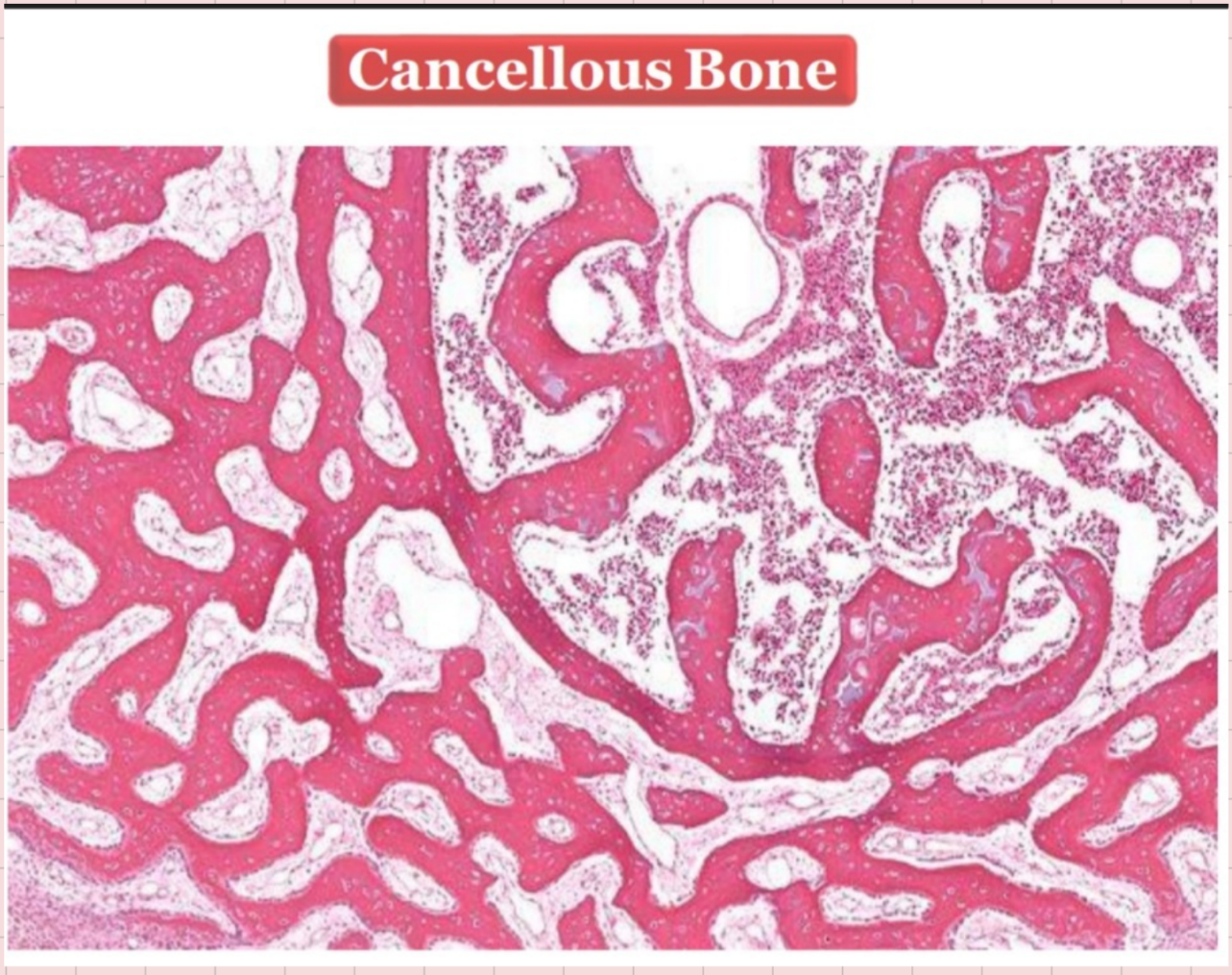
2. What is cancellous bone composed of?
   - Cancellous bone is made up of branching trabeculae of spongy bone, which are composed of irregularly arranged lamellae.

3. What distinguishes cancellous bone from compact bone in terms of structure?
   - Cancellous bone does not have Haversian systems, unlike compact bone.

4. How are the bone cells in cancellous bone nourished?
   - The bone cells in cancellous bone are nourished by diffusion of tissue fluid through the canaliculi from the bone marrow cavities.

5. Describe the appearance of bone marrow cavities in cancellous bone.

- Bone marrow cavities appear as irregular cavities in between bone trabeculae of cancellous bone and contain blood cells.



Osteogenesis:

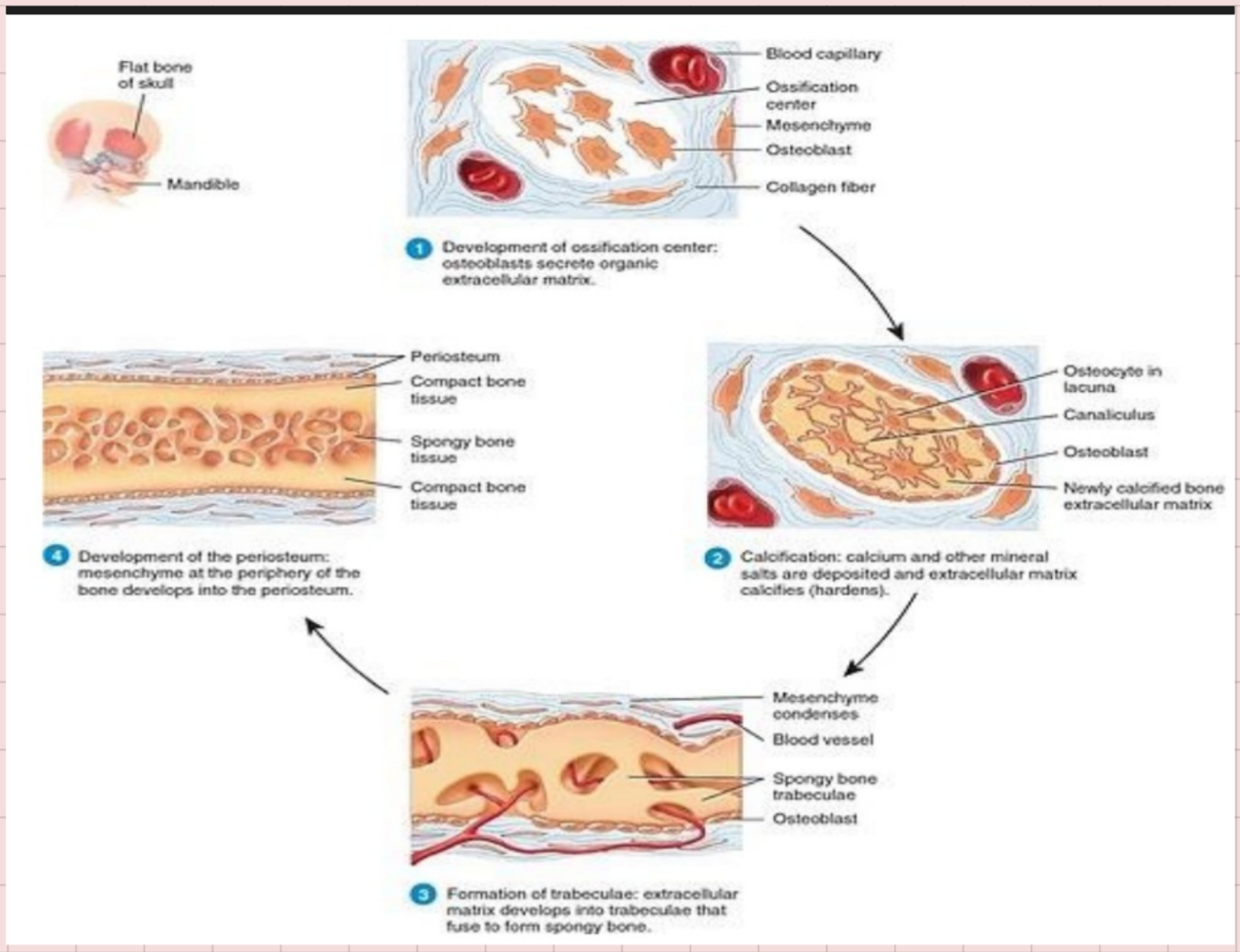
I) Intramembranous Ossification:

1. What is intramembranous ossification?
   - Intramembranous ossification is a process by which most flat bones begin to form. It is called so because it takes place within condensations ("membranes") of embryonic mesenchymal tissue.

2. Which bones are initially produced by intramembranous ossification?
- The frontal and parietal bones of the skull, as well as parts of the occipital and temporal bones, and the mandible and maxilla are initially produced by intramembranous ossification.

3. What are ossification centers?
- Ossification centers are the starting points for bone formation within the condensed layer of mesenchyme.

4. What happens within ossification centers?
- Within ossification centers, mesenchymal cells differentiate into osteoprogenitor cells, which proliferate and form incomplete layers of osteoblasts around a network of developing capillaries.



Osteogenesis (Intramembranous Ossification - Continued):

5. What do polarized osteoblasts secrete, and what do these secretions form?

- Polarized osteoblasts secrete the osteoid components, which calcify and form trabeculae of woven bone.

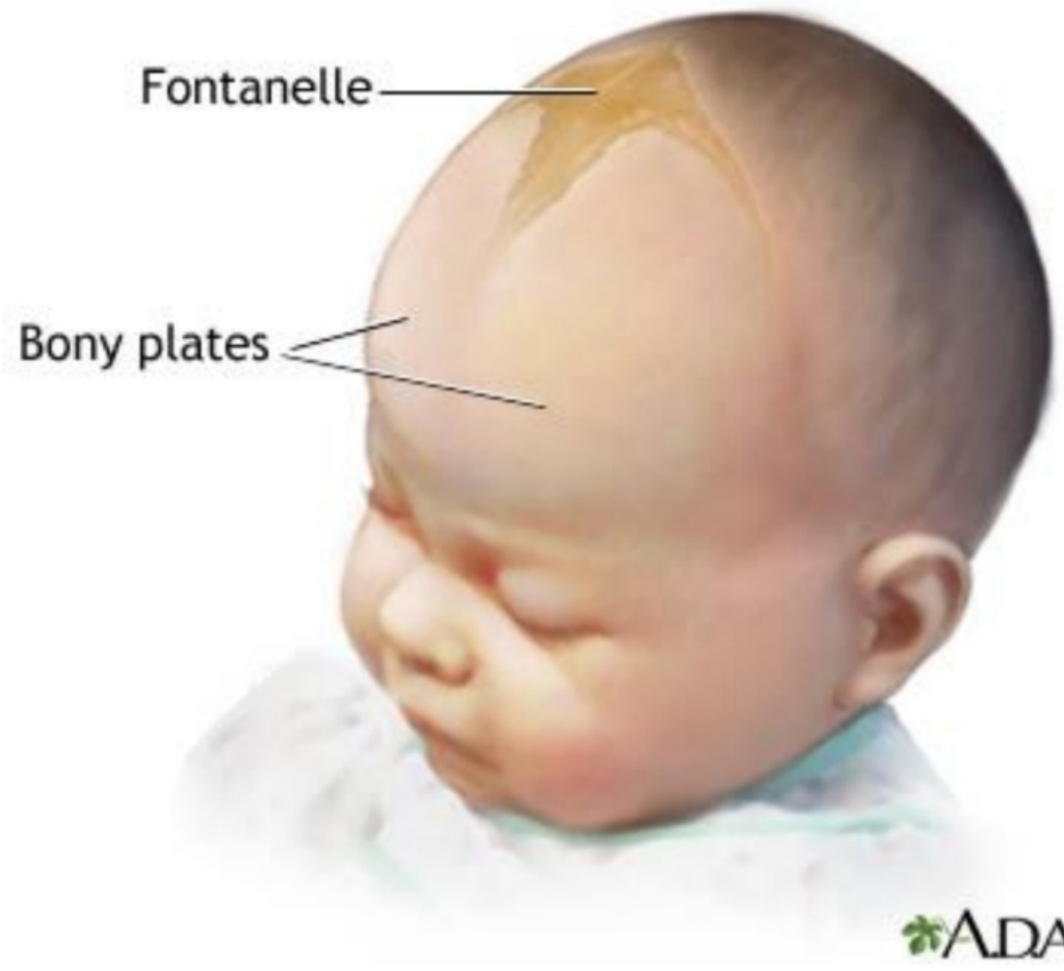
6. How do differentiating osteocytes maintain intercellular contacts within the matrix?

- Differentiating osteocytes, now enclosed within matrix lacunae, retain intercellular contacts via their

thin cytoplasmic processes within matrix canaliculi.

7. What processes lead to the fusion of neighboring ossification centers and trabecular growth?
- Continued matrix secretion, calcification, and trabecular growth lead slowly to the fusion of neighboring ossification centers.

8. What is the result of continued bone formation in cranial flat bones?
- In cranial flat bones, bone formation predominates over bone resorption at both the internal and external surfaces. This results in the formation of two layers of compact bone (internal and external plates), while the central portion (diploë) maintains its cancellous, spongy nature. The fontanelles or “soft spots” on the heads of newborn infants are
areas in the skull that correspond to parts of the connective tissue that
are not yet ossified. Regions of the connective tissue that do not
undergo ossification give rise to the endosteum and the periosteum of
the new bone



Osteogenesis (Endochondral Ossification):

II) Endochondral Ossification:

1. What is the initial step in endochondral ossification?
   - Ossification takes place within a piece of hyaline cartilage, resembling a small version or model of the bone to be formed.

2. What bones does endochondral ossification principally initiate, and which bones are especially well studied in this process?
- Endochondral ossification principally initiates most bones of the body and is especially well studied in developing long bones.

3. How does the first bone tissue appear in endochondral ossification?
- The first bone tissue appears as a collar surrounding the diaphysis of the cartilage model. This bone collar is produced by the activity of osteoblasts within the surrounding perichondrium.

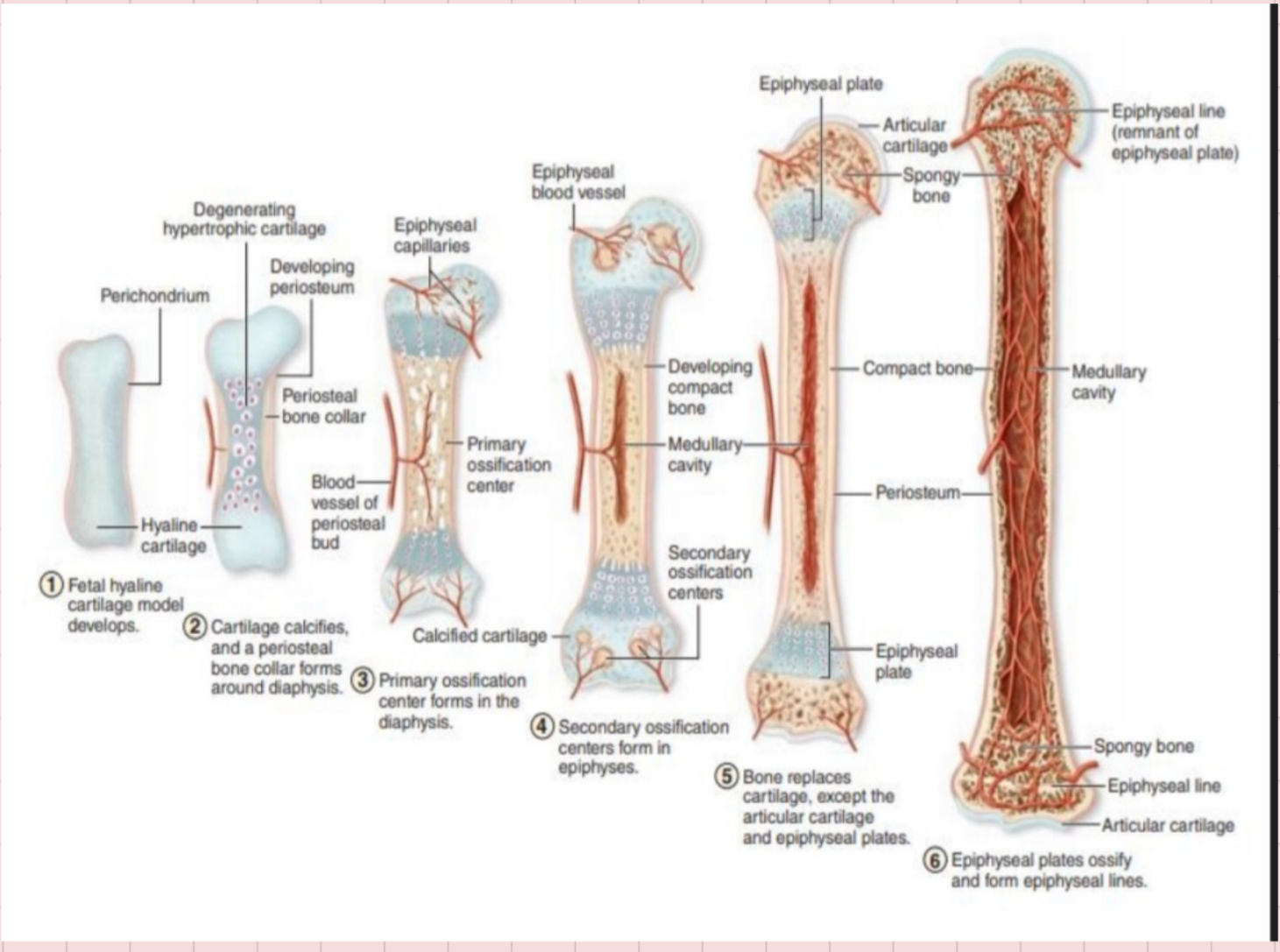
4. What is the function of the bone collar in endochondral ossification?
- The bone collar inhibits diffusion of oxygen and nutrients into the underlying cartilage, promoting degenerative changes there.

5. What changes occur in chondrocytes during endochondral ossification?
- Chondrocytes begin to produce alkaline phosphatase and swell up (hypertrophy), enlarging

their lacunae. These changes compress the matrix into narrow trabeculae and lead to calcification in these structures.

6. What happens after the death of chondrocytes in endochondral ossification?

- Death of the chondrocytes creates a structure consisting of calcified cartilage remnants, which become covered by a layer of osteoblasts.



**Osteogenesis (Endochondral Ossification -

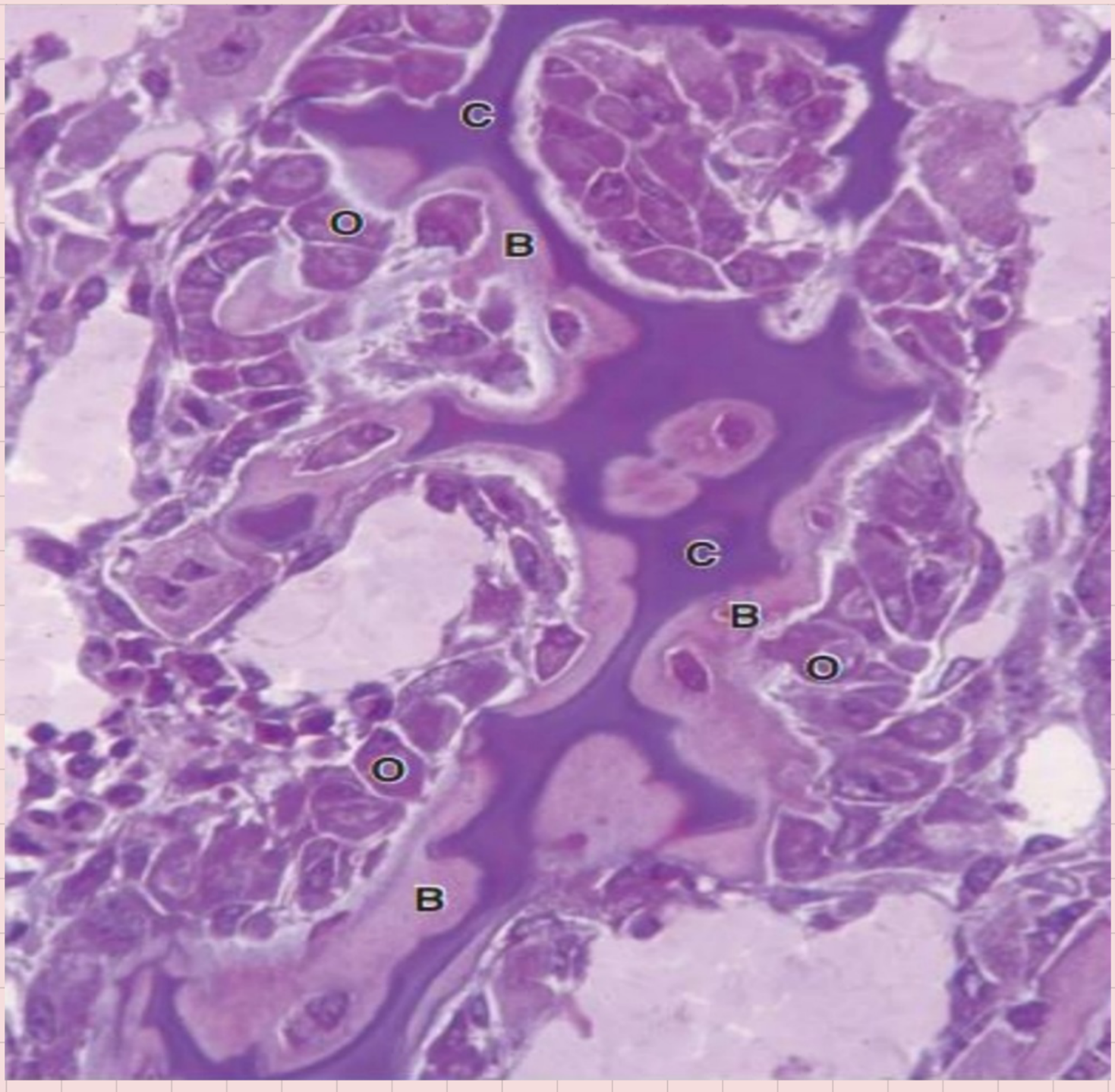
Continued):**

7. What do osteoblasts do next in endochondral ossification?
   - Osteoblasts adhere to the remnants of the calcified cartilage matrix and produce woven bone.

8. How does the appearance of the calcified cartilage change during this stage of endochondral ossification?
   - The calcified cartilage at this stage appears basophilic, while the new bone produced by osteoblasts is more acidophilic.

9. How do blood vessels contribute to the process of endochondral ossification?
   - Blood vessels from the perichondrium (now the periosteum) penetrate through the bone collar, bringing osteoprogenitor cells to the central region.

10. What does the process in the diaphysis form, and when does it begin in many bones?
    - This process in the diaphysis forms the primary ossification center, beginning in many bones as early as the first trimester.



Osteogenesis (Endochondral Ossification - Continued):

11. When do secondary ossification centers appear, and where do they develop?
    - Secondary ossification centers appear later at

the epiphyses of the cartilage model and develop in a similar manner to the primary ossification centers.

12. What occurs during the expansion and remodeling of primary and secondary ossification centers?
- During their expansion and remodeling, the primary and secondary ossification centers produce cavities that are gradually filled with bone marrow and trabeculae of bone.

13. What regions of cartilage remain with the presence of primary and secondary ossification centers?
- Two regions of cartilage remain:
  - The layer of articular cartilage within joints, which usually persists through adult life and does not contribute to bone growth.
  - The epiphyseal cartilage (also called epiphyseal plate or growth plate), which connects each epiphysis to the diaphysis.

14. What is the function of the epiphyseal cartilage?
- The epiphyseal cartilage is responsible for the growth in length of the bone and disappears at

adulthood.

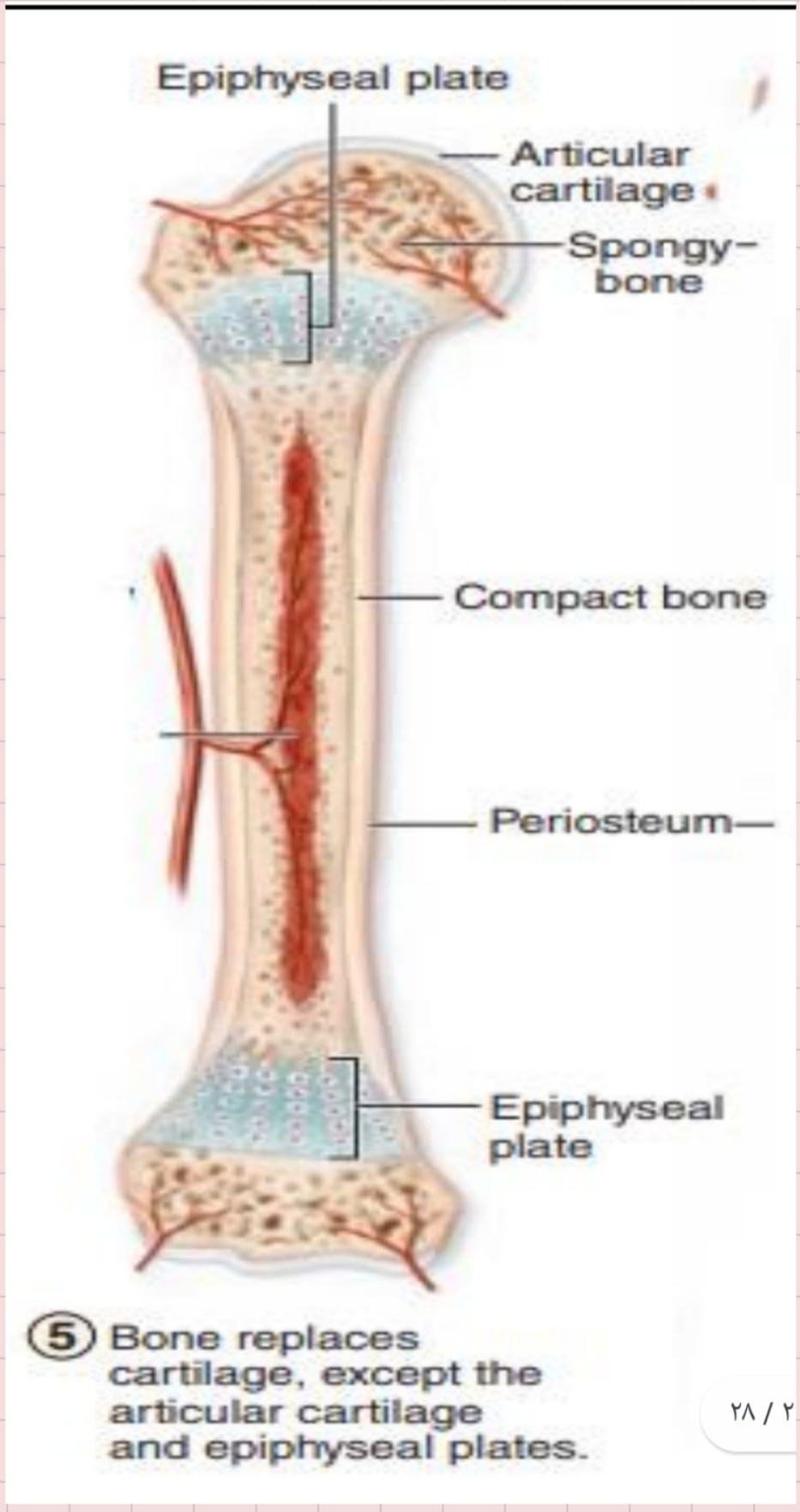
15. When does epiphyseal closure occur, and what does it signify?
    - Epiphyseal closure occurs at different times with different bones and is complete in all bones by about age 20. It signifies the cessation of bone growth in length.

Bone Age Determination:

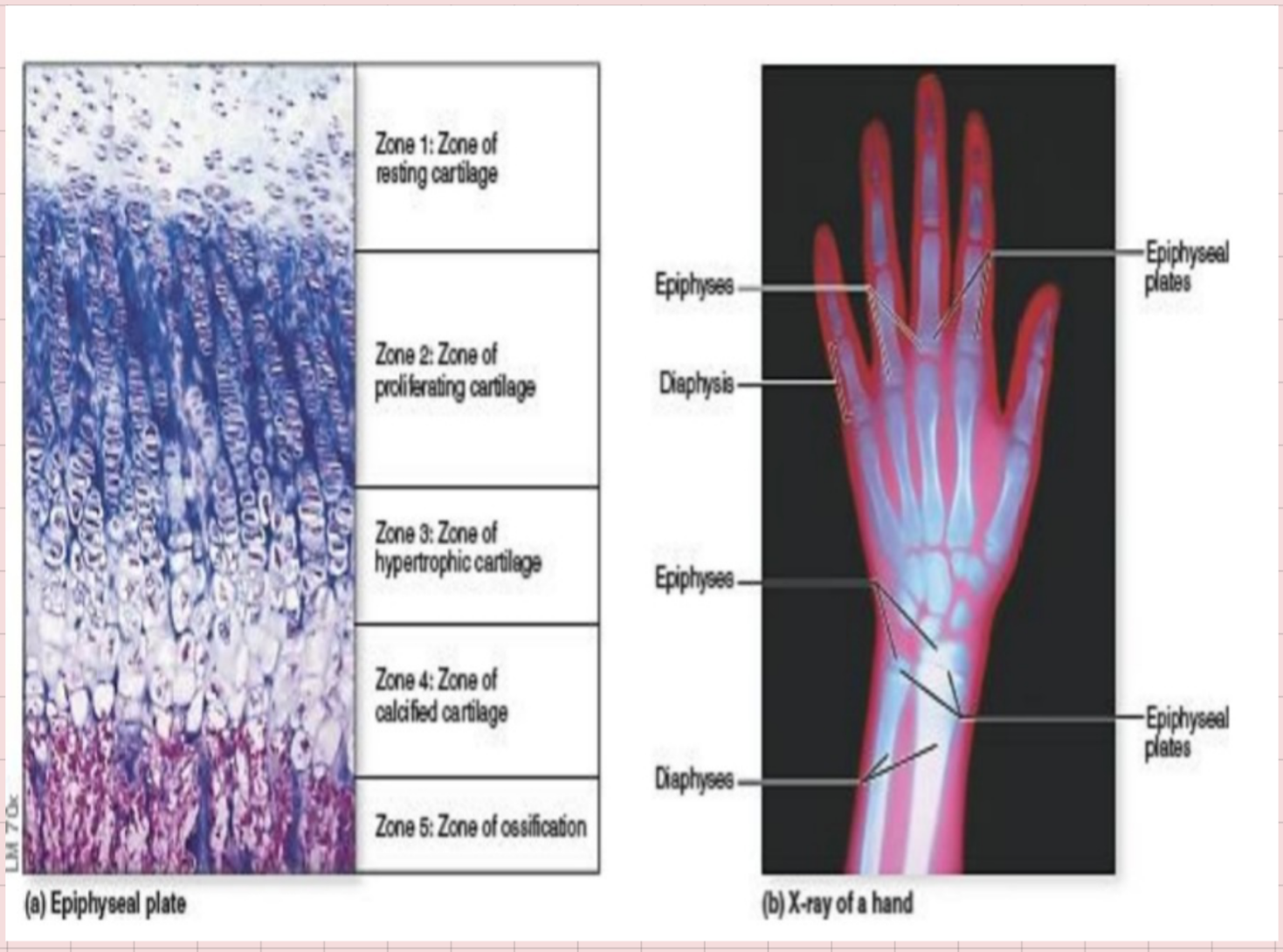
1. How is bone age determined in forensic or X-ray examinations of the growing skeleton?
    - Bone age is determined by noting which epiphyses are open and which are closed.

2. What does the closure of epiphyses indicate?
    - The closure of epiphyses indicates the end of longitudinal bone growth.

3. What happens once the epiphyses have closed?
    - Once the epiphyses have closed, additional growth in length of bones is no longer possible, although bone widening may still occur.



⑤ Bone replaces cartilage, except the articular cartilage and epiphyseal plates.



Epiphyseal Growth Plate Zones:

1. What is the composition of the resting zone in the epiphyseal growth plate?
    - The resting zone consists of hyaline cartilage with typical chondrocytes.

2. What happens in the proliferative zone of the epiphyseal growth plate?
    - In the proliferative zone, chondrocytes begin to divide rapidly and form columns of stacked cells parallel to the long axis of the bone.

3. Describe the characteristics of the hypertrophic cartilage zone.

- The hypertrophic cartilage zone contains swollen, degenerative chondrocytes with accumulated glycogen. This hypertrophy compresses the matrix into thin septa between the chondrocytes.

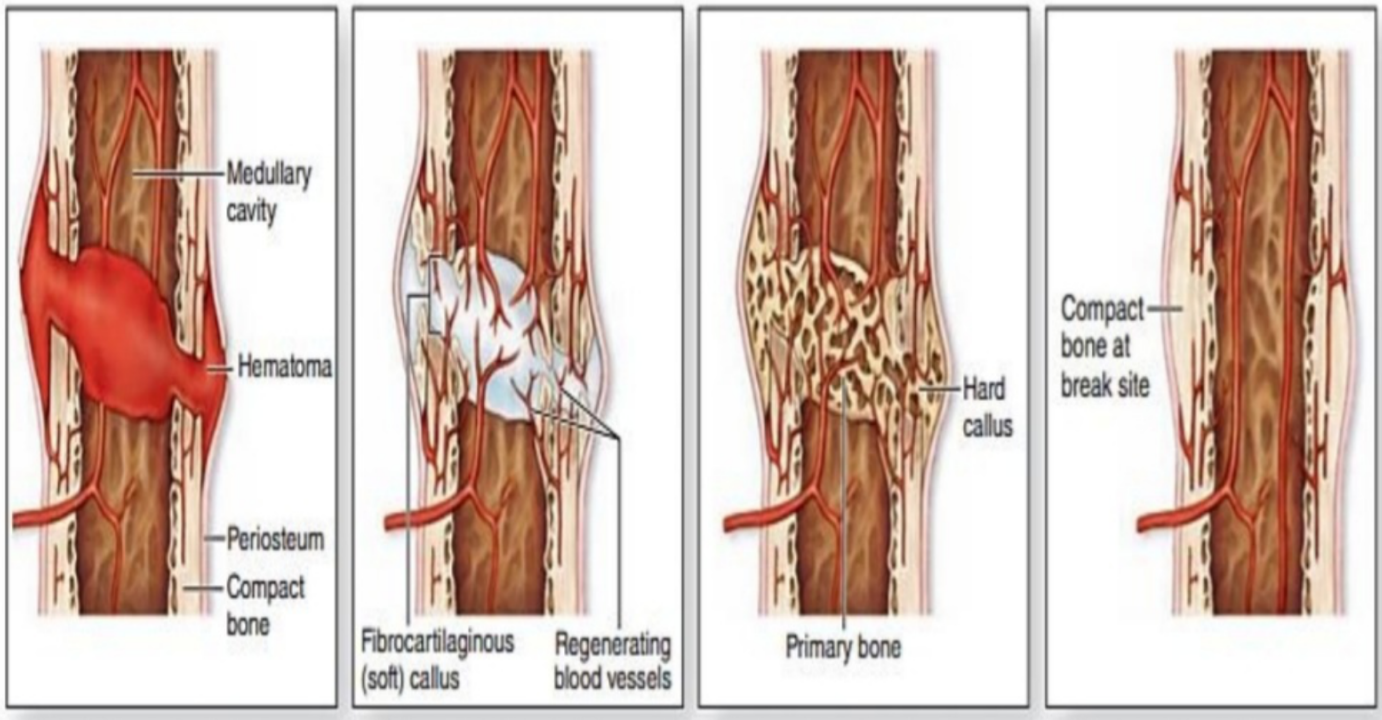
4. What occurs in the calcified cartilage zone of the epiphyseal growth plate?

- In the calcified cartilage zone, loss of the chondrocytes by apoptosis is accompanied by calcification of the septa of cartilage matrix due to the formation of hydroxyapatite crystals.

5. Explain the events in the ossification zone of the epiphyseal growth plate.

- In the ossification zone, capillaries and osteoprogenitor cells from the periosteum invade the cavities left by the chondrocytes. Osteoblasts settle in a layer over the septa of calcified cartilage matrix and secrete osteoid over these structures, forming woven bone.

features of bone fracture repair



(a) A fracture hematoma forms. (b) A fibrocartilaginous (soft) callus forms. (c) A hard (bony) callus forms. (d) The bone is remodeled.

Bone Fracture Repair Process:

(a) What occurs initially when blood vessels within a fracture are torn?

- Blood vessels torn within the fracture release blood that clots to produce a large fracture hematoma.

(b) Describe the next step in the bone fracture repair process.

- The fracture hematoma is gradually removed by

macrophages and replaced by a soft fibrocartilage-like mass of procallus tissue rich in collagen and fibroblasts. If broken, the periosteum reestablishes continuity over this tissue.

(c) What happens to the soft procallus tissue in the bone fracture repair process?

- The soft procallus tissue is invaded by regrowing blood vessels and osteoblasts. In the next few weeks, the fibrocartilage is gradually replaced by trabeculae of woven bone, forming a hard callus throughout the original area of fracture.

(d) Describe the final stages of bone fracture repair.

- The woven bone is then remodeled as compact and cancellous bone in continuity with the adjacent uninjured areas, and fully functional vasculature is reestablished.